(12) UK Patent Application (19) GB (11) 2 370 766 (13) A

(43) Date of A Publication 10.07.2002

(21) Application No 0100530.5

(22) Date of Filing 09.01.2001

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(51) INT CL[7]
A62C 35/02

(52) UK CL (Edition T)
A5A A20X4 A6

(56) Documents Cited
WO 95/28204 A1 US 5887662 A
US 5799735 A

(58) Field of Search
UK CL (Edition S) A5A A14H A20X4 A6 A7 A9
INT CL[7] A62C 35/02 39/00
ONLINE: WPI EPODOC JAPIO

(54) Abstract Title
Fire and explosion suppression system and method generating a fine mist of liquid suppressant entrained in inert gas

(57) A fire and explosion suppression system comprises a source, such as vessel 5, of liquid suppressant such as water and a source of pressurised gas, such as vessel 14, which gas and liquid are mixed together in a mixing means 6 to produce a fine mist of liquid suppressant entrained in an inert gas and transporting the mix to separate discharge means 26, 28. The liquid droplet size is typically between 5 and 60 micrometres and may be controlled by variation of the initial contact pattern between the liquid and gas using variation in mixing means 6 entry routes 12A, and the speed of entry using pressure regulators 8,16 and flow regulators 10,18. The mixing means may alternatively comprise a venturi arrangement (6a, fig.2). The liquid may contain a further fire suppressant additive such as potassium hydrogen carbonate. Also disclosed is a method of fire and explosion suppression which comprise the steps of mixing a pressurised liquid suppressant and a pressurised inert gas to produce a mist of the liquid and entraining the mist in the pressurised gas and transporting it at high velocity for separate discharge. The output of the system and/or method may be a mist of very small droplet size to produce a "total flooding" effect in an area.

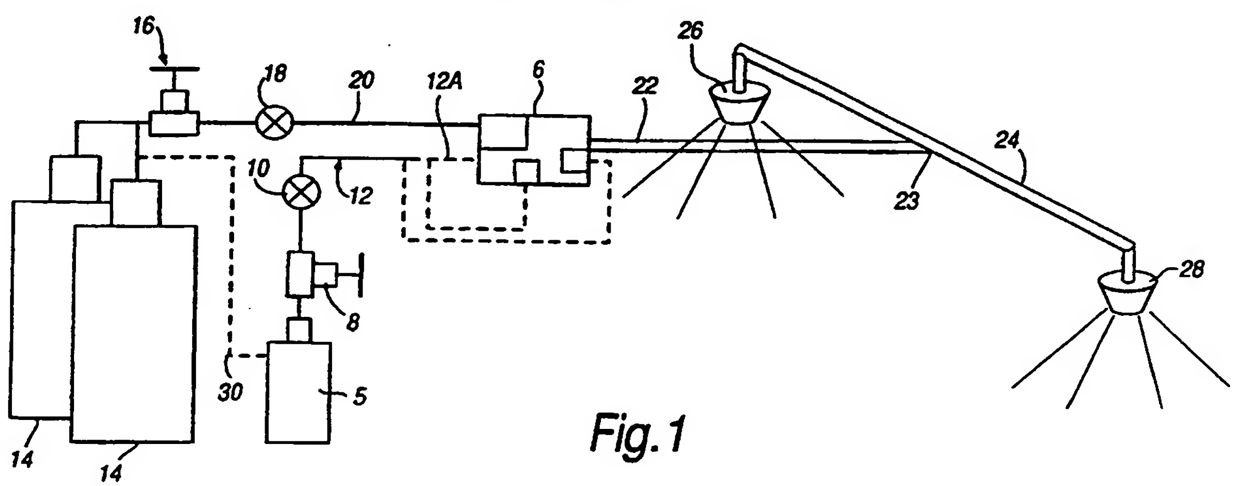

Fig.1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

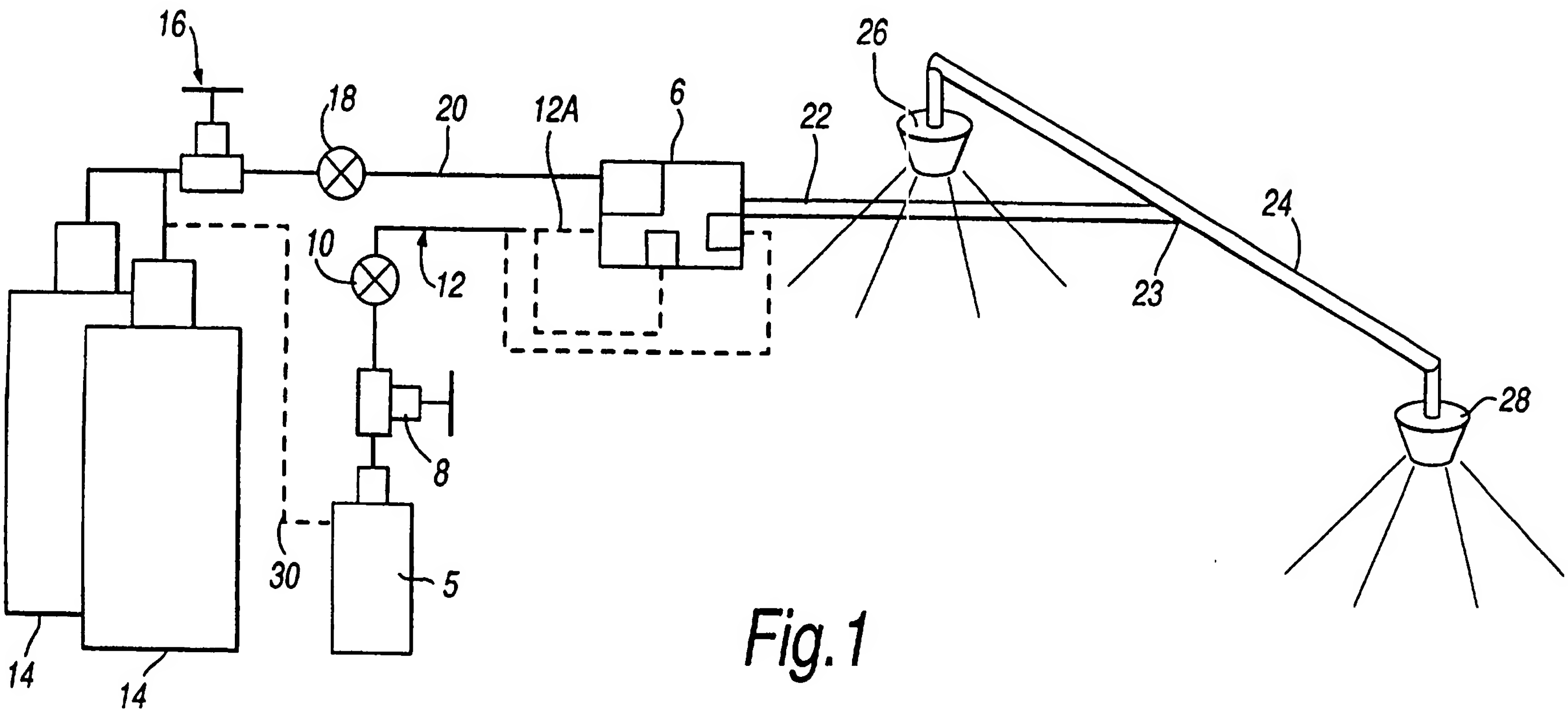


Fig.1

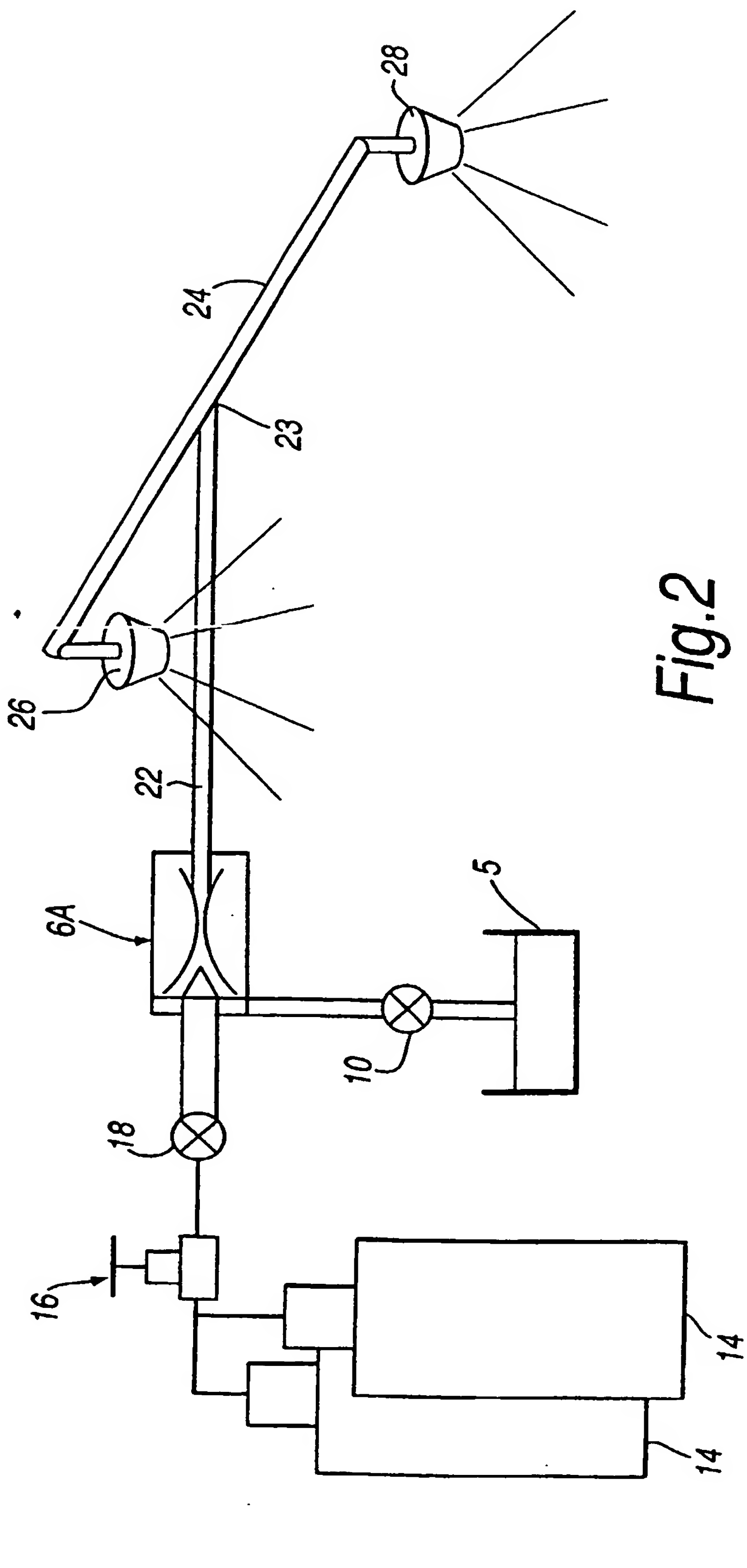
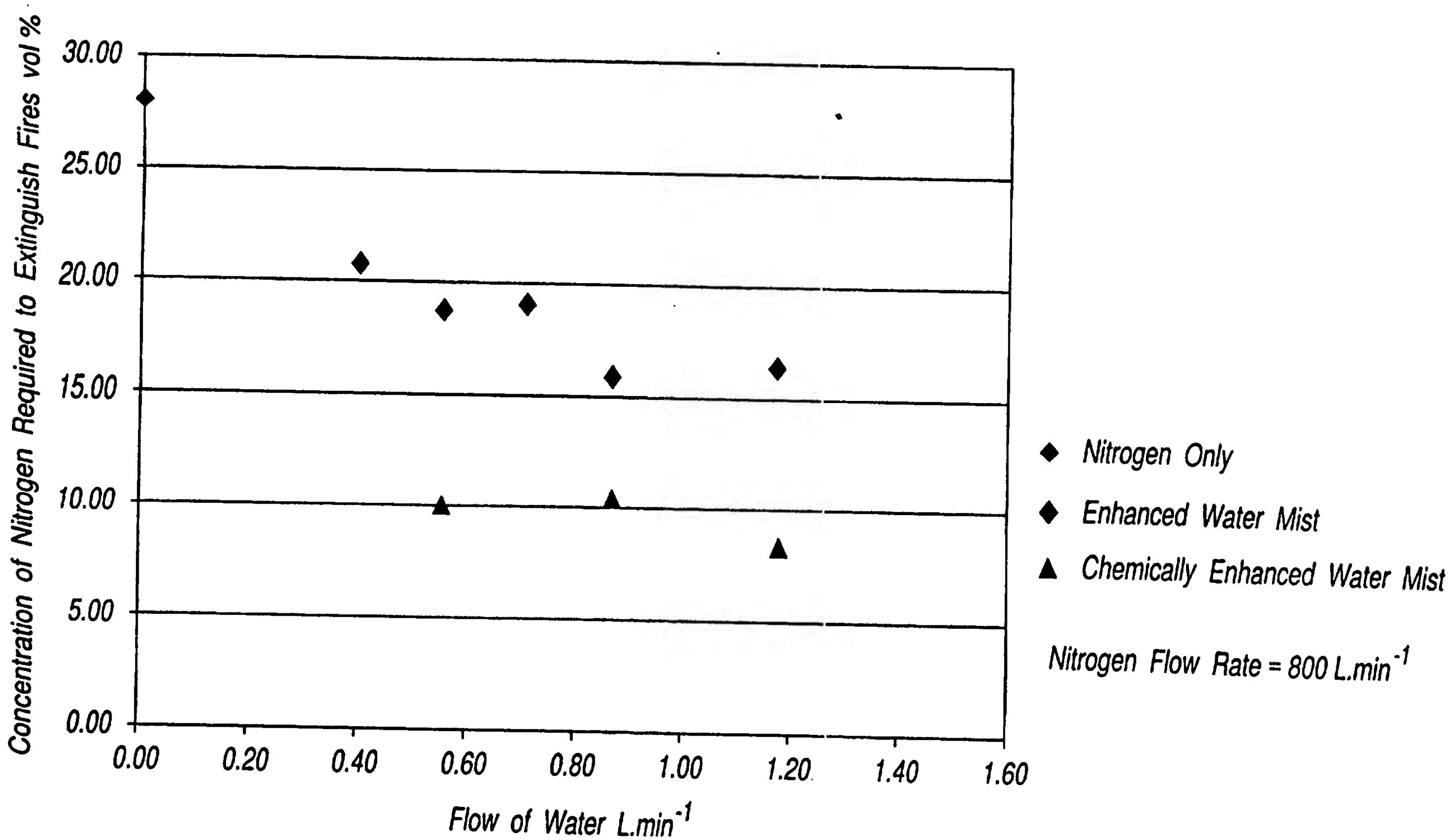


Fig.2



Concentration of Nitrogen Required to Extinguish Fires vol %
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
Flow of Water L.min-1
Nitrogen Only
Enhanced Water Mist
Chemically Enhanced Water Mist
Nitrogen Flow Rate = 800 L.min-1

Fig.3

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FIRE AND EXPLOSION SUPPRESSION

The invention relates to fire and explosion suppression. Embodiments of the invention, to be described below by way of example only, use water mist as the suppression agent.

According to the invention, there is provided a fire and explosion suppression system, comprising a source of a pressurised liquid suppressant and a source of pressurised inert gas which are fed to mixing means to produce a mist of the liquid, and means for entraining the mist in the pressurised gas and transporting it at high velocity to separate discharge means.

According to the invention, there is further provided a fire and explosion suppression method, comprising the steps of mixing a pressurised liquid suppressant and a pressurised inert gas to produce a mist of the liquid, and entraining the mist in the pressurised gas and transporting it at high velocity for separate discharge.

Fire and explosion suppression systems and methods according to the invention, employing water mist, will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a schematic diagram of one of the systems;

Figure 2 shows a modification to the system of Figure 1; and

Figure 3 is a graph illustrating minimum extinguishing concentrations achievable with some of the systems.

Referring to Figure 1, a system shows a vessel 5 storing water (or other suitable suppressant liquid). The vessel 5 is connected to an input of a mixing unit 6 via a pressure regulator 8, a flow regulator 10 and a pipe 12. The dotted lines 12A,12B and 12C show alternative connections of the pipe 12 to the mixing device 6, as will be described in more detail below.

The system also includes a vessel 14 storing an inert gas such as nitrogen, or other propelling gas. Vessel 14 has an outlet connected via a pressure regulator 16, a flow regulator 18 and a pipe 20 to another input of the mixing unit 6. The mixing unit 6 has an outlet pipe 22 which connects with a distribution pipe 24 terminating in spreader or distribution heads 26,28.

In use, water from the vessel 5 and gas from the vessel 14 are fed under high pressure into the mixing unit 6 through the pressure regulators 8 and 16 and through the flow regulators 10 and 18 which regulate the pressure and flow rate. The mixing unit 6 comprises a hollow chamber into which the water and gas are discharged. Within the mixing chamber, the gas causes the water to be formed into a mist made up of droplets of small size, preferably in the range of between 5 and 60 micrometres. The water mist is produced partly by a shearing action of the gas on the water. The droplet size may be influenced by the relative directions with which the water and the gas enter the mixing

unit 6. Thus, if the water enters through pipe portion 12A, it will enter in a direction substantially parallel to the direction of the gas. If the water enters via pipe portion 12B, it will enter substantially at right angles to the gas, and the shearing action will be greater. If the water enters through pipe portion 12C, it will enter in a direction opposition to that of the gas, and the shearing action may be greater still. In this way, the droplet size in the mist can be controlled. In addition, the droplet size can be controlled by altering the proportions, relative flow rates and/or relative pressures of the water and the gas.

The water in the vessel 5 may be pressurised by a separate pressure source not shown. Instead, though, it could be pressurised by the gas within the vessel 14, via an interconnection 30.

The mist exits the mixing chamber 6 along the outlet pipe 22 to a T-junction 23, thence along the distribution pipe 24 and exits from the spreaders 26,28 into the volume to be protected.

It is an important feature of the system being deFigure 2 shows a modification in which the mixing means 6 is replaced by an eductor 6A which uses a venturi effect. High pressure gas from the vessel 14 passes via the flow regulator 18 into the eductor 6A where the venturi effect cdauses a low pressure area to be formed. This low pressure area draws water from the vessel 5 via the flow regulator which may be at low pressure or unpressurised. A mist is formed at the point of intersection between the two fluids. This mist exits along the pipe 22 to remainder of the pipe system in the manner described with reference to Figure 1.

Because the water droplets have a smaller size than for existing water mist systems, they will remain suspended for longer.

In this way, the system can have a "total flooding" capability – that is, for substantially filling a volume where an explosion or fire is detected and is to be extinguished.

The presence of the inert gas in the discharged water mist increases the efficiency of extinguishing and suppression.

The improved production of water mist, stemming from the separation of the water mist producing stage and the mist discharging stage, and the transmission of the mist at high velocity and under high pressure along a combined pipe between these two stages, enables a water mist system to be produced which requires substantially less stored gas.

In a modification, a suitable chemical agent is added to the water to improve the extinguishing and suppressing action. A suitable chemical agent is potassium hydrogen carbonate ($KHCO_3$). The presence of this chemical agent in the final mist increases the efficiency of fire and explosion suppression very significantly.

For systems such as high rate discharge explosion protection suppressors or hand extinguishers, the mixing chamber or eductor would be situated either within or close to the suppressant storage cylinder but prior to the "main" distribution pipework, which would be the nozzle housing for HRD suppressors or the external hose for hand

extinguishers.

In order to test the operation of a system similar to that shown in the Figure (but having a single spreader outlet), experiments were carried out in a $1m^3$ test chamber. Eight 50 mm diameter and 50 mm deep panfires were filled with water and n-Heptane, and placed on shelves or stands which were evenly distributed within the test chamber. Each fire was partially baffled, which helped to reduce the effects of flame stretching caused by the flow of suppressant into the chamber. The spreader was screwed inside the chamber, at the centre of its top.

All eight fires were ignited and allowed to burn for 30 seconds. The test chamber was then closed. After a total of 50 seconds, nitrogen alone was discharged into the chamber by the system for a predetermined time.

The flow of nitrogen was adjusted until the fires had been extinguished. When the minimum extinguishing concentration for nitrogen had been achieved for the chamber, the experiments were repeated adding known flows of water to the flow of nitrogen. The resultant enhanced water mist provided better extinguishing properties and a new minimum extinguishing concentration was established. Further fire tests were carried out using water and potassium bicarbonate solution as the added suppressant to the flow of nitrogen. As before, minimum extinguishing concentrations were established.

After the fire testing had been completed, analysis was carried out on the water droplet sizes produced by the enhanced water mist generation system.

The results of the experiments can be summarised as follows:

The minimum extinguishing concentration for nitrogen (baseline tests) using the above apparatus and a flow rate of 800 L/min, was 29 vol%.

The minimum extinguishing concentration for nitrogen and enhanced water mist was 16 vol%. This was achieved when 0.87 L/min of water was added to 800 L/min of nitrogen. The results show that enhanced water mist requires 45% less nitrogen to suppress the same fires when compared to the nitrogen baseline results.

The minimum extinguishing concentration for nitrogen and chemically enhanced water mist was 8.5 vol%. This was achieved when 1.2 L/min of potassium bicarbonate solution was added to 800 L/min of nitrogen. These results show that enhanced chemical water mist requires 70% less nitrogen to suppress the same fires when compared to the nitrogen baseline results.

The average water droplet sizes that produced the most effective results in the fire test programme were $D_{v=0.1} = 6.3\ \mu m$, $D_{v=0.5} = 26.3\ \mu m$, and $D_{v=0.9} = 78.5\ \mu m$ (where $D_{v=0.5}$ is the mean droplet size, 10% of the droplets have a diameter below $D_{v=0.1}$, and 90% of the droplets have a diameter below $D_{v=0.9}$)

Some of the test results showing minimum extinguishing concentrations are illustrated in Figure 3.

CLAIMS

1. A fire and explosion suppression system, comprising a source of a liquid suppressant and a source of pressurised inert gas which are fed to mixing means to produce a mist of the liquid, and means for entraining the mist in the pressurised gas and transporting it at high velocity to separate discharge means.

2. A system according to claim 1, in which the medium droplet size of the water mist lies between 5 and 60 micrometres.

3. A system according to claim 1 or 2, in which the mixing means comprises means defining a chamber for receiving the liquid suppressant under pressure and the pressurised gas such that they mutually impinge.

4. A system according to claim 3, in which the pressurised liquid suppressant and the pressurised gas impinge on each other substantially perpendicularly.

5. A system according to claim 3, in which the pressurised liquid suppressant and the pressurised gas impinge at substantially 180° to each other.

6. A system according to claim 1 or 2, in which the mixing means comprises eduction means responsive to the gas for educting the liquid suppressant and producing the said mist.

7. A system according to any preceding claim, in which the discharge means comprises at least one outlet and in which the entraining and transporting means comprises narrow pipe means interconnecting the mixing means with the outlet.

8. A system according to claim 7, in which the Reynolds number effective in the pipe means is at least 4000.

9. A system according to claim 8, in which the Reynold's number is at least 12000.

10. A system according to any preceding claim, in which the sources of liquid suppressant and of the inert gas are connected to the mixing means by pipe means and the mixing means is at least 1 metre downstream of any flow restrictor in this pipe means.

11. A system according to any preceding claim, in which the liquid suppressant comprises water.

12. A system according to claim 11, in which the liquid is mixed with a chemical fire suppressant carried by the mist.

13. A system according to claim 12, in which the chemical fire suppressant is potassium hydrogen carbonate.

14. A system according to any preceding claim, in which the pressurised gas is nitrogen.

15. A system according to any one of claims 1 to 13, in which the pressurised gas is argon.

16. A system according to any one of claims 1 to 13, in which the pressurised gas is a nitrogen and argon mixture.

17. A fire and explosion suppression method, comprising the steps of mixing a pressurised liquid suppressant and a pressurised inert gas to produce a mist of the liquid, and entraining the mist in the pressurised gas and transporting it at high velocity for separate discharge.

18. A method according to claim 17, in which the median droplet size of the water mist lies between 5 and 60 micrometres.

19. A method according to claim 17 or 18, in which the pressurised liquid suppressant and the pressurised gas are mixed by mutually impinging them.

20. A method according to claim 19, in which the pressurised liquid suppressant and the pressurised gas impinge on each other substantially perpendicularly.

21. A method according to claim 19, in which the pressurised liquid suppressant and the pressurised gas impinge at substantially 180° to each other.

22. A method according to any one of claims 17 to 218, in which the water mist is

entrained and transported while being longitudinally and cross-sectionally confined.

23. A method according to claim 22, in which the water mist is entrained and transported in conditions in which the effective Reynold's number is at least 4000.

24. A method according to claim 21, in which the Reynold's number is at least 12000.

25. A method according to any one of claims 12 to 24, in which the liquid suppressant comprises water.

26. A method according to claim 25, in which the liquid is mixed with a chemical fire suppressant carried by the mist.

27. A method according to claim 26, in which the chemical fire suppressant is potassium hydrogen carbonate.

28. A method according to any one of claims 17 to 27, in which the pressurised gas is nitrogen.

29. A method according to any one of claims 17 to 27, in which the the pressurised gas is nitrogen.

30. A method according to any one of claims 17 to 27, in which the pressurised gas is a nitrogen and argon mixture.

31. A fire and explosion suppression system, substantially as described with reference to Figure 1 of the accompanying drawings.

32. A fire and explosion suppression method, substantially as described with reference to Figure 1 of the accompanying drawings.